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JANENE PEISKER
TEAM LEADER EXAMINATION
SUPPORT AND SALES

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PROVISIONAL SPECIFICATION

Invention Title: **Multidirectional transmission**

The invention is described in the following statement:

Multidirectional transmission

Field of the invention

The present invention relates to multidirectional transmission for a hand-tool.

Background of the invention

Hand-tools, and in particular handheld drills are known which have transmissions that can drive a rotating tool about an axis aligned at an angle relative to the drive motor of the hand-tool. United States patent no. 5,020,281 discloses a rotary hand-tool with an angularly adjustable head. The hand-tool has a transmission including a flexible drive cable that provides rotational drive from the tool's motor to the head. The tool's head includes a geared mechanism which drives the tool about an axis of rotation set perpendicularly to the axis of rotation of the incoming drive cable. Moreover the angle of the head can be changed in use to allow a user to select the angle of the rotation axis of the tool.

International patent application PCT/IB97/01347 (published as International publication no. WO 99/21686) also describes a multidirectional transmission which uses a flexible drive cable to transmit power from the drive motor to the tool.

The present inventors have found that multidirectional or angular transmissions having a flexible drive cable of the type including at least one axially extending core strand surrounded by one or more of helically wound strand wrapped around the core, have a number of disadvantages.

The most critical disadvantage with such transmissions is that the drive cord is prone to breakage either with extended use, or through the application of excessive torque to the tool. It has also been found that using a cord drive allows excessive backlash or "play" in tool bit due to the deformation of the cord when torque is applied to it. It has further been found that using a flexible cord drive is disadvantageous in applications (such as cordless screwdrivers) in which the direction of the rotation can be changed from clockwise to anticlockwise as breakage of the drive cord may occur due to the effective unwinding of the outer layers of the drive cord.

The present inventors have also discovered that the abovementioned problems increase with increasing length of the drive cord, thus substantially limiting the maximum length of a transmission driven by a flexible cable.

One solution to overcome the disadvantages of transmissions using flexible drive cables is to use a transmission having plurality of bevel gears which are arranged so as to offset the rotation axis of the drive shaft from the rotation axis of the driven shaft. However such devices are also prone to failure, e.g. due to the teeth shearing off the gears, under high load.

Summary of the invention

In broad concept the present invention provides a transmission for a rotary hand-tool which has an input shaft and an output shaft connected by one or more universal joints which allows the orientation of the input and output shafts to be angularly varied relative to each other.

In a first aspect there is provided a transmission for a hand-tool including:

a drive shaft having a first axis of rotation and a driven shaft having a second axis of rotation; the drive shaft and driven shaft being rotationally coupled through at least one universal joint;

a housing configured to receive said drive shaft and driven shaft, and configured to enable the relative orientation of the axis of rotation of the drive shaft and the axis of rotation of the driven shaft to be varied.

Preferably the housing includes an input end configured to receive the drive shaft and an output end configured to receive the driven shaft and is articulated to allow the relative orientation of the axis of rotation of the drive shaft and the axis of rotation of the driven shaft to be varied.

Preferably the transmission includes one or more intermediate shafts coupled between the drive shaft and the driven shaft. Preferably each intermediate shaft is coupled to an adjacent shaft via a universal joint.

The housing preferably includes at least two substantially cylindrical housing elements arranged end to end, said housing elements having a passage formed

therethrough lying substantially along an axis of the housing and being configured to receive the transmission shafts.

Preferably the housing elements further include a seating surface lying in a plane set at oblique angle to the axis of the housing element, and configured to abut a corresponding seating surface of an adjacent housing element, wherein the relative orientation of adjacent housings elements can be adjusted by rotating the adjacent housing elements about the axis of the housing elements in the plane of the seating surfaces.

Preferably the planes in which the seating surfaces of adjacent housing elements lie form a supplementary angle with each other such that in a first relative orientation the housing elements are coaxial.

Preferably the housing includes three housing elements.

Preferably the housing includes locking means configured to allow the drive shaft and driven shaft to be locked in a selected orientation.

In further aspects the present invention provides a hand tool including a transmission as described above and a kit including a transmission as described above and configured to be retrofitted to a hand-tool.

Brief description of the drawings

Preferred embodiments of the present invention will now be described by way of non-limiting example only with reference to the accompanying drawings in which:

Figure 1A shows a schematic cut away view of a multidirectional transmission according to a first embodiment of the present invention;

Figure 1B shows the multidirectional transmission of Figure 1 in a first angular orientation;

Figure 1C shows the angular transmission of Figures 1 and 2 in and the angular orientation;

Figure 2 shows a multidirectional transmission according to an embodiment of the present invention mounted on a hand drill;

Figure 2A shows the transmission of Figure 2 in a first selected orientation;

Figure 2B shows the transmission of Figure 2 in a second selected angular orientation;

Figure 2C shows the transmission of Figure 2 in another selected angular orientation;

Figure 3 shows a top view of the transmission of Figure 2 in yet another angular orientation; and

Figure 4 shows a perspective view of the clamping collar used in an embodiment of the present invention.

Detailed description of the embodiments

Embodiments of the present invention will now be described with reference to an example of a transmission fitted to a powered hand-drill, however the present invention should not be considered to be limited to use in this application but should be considered to be applicable to hand tools in general of the type in which rotational motion is transmitted from a drive shaft to a driven shaft. For example a transmission of the present invention could be used in connection with an angle grinder, router, powered screwdriver, or the like.

Figure 1A shows the cutaway side view of a multidirectional transmission configured to be fitted to a powered hand drill. The transmission 100 includes housing 102 and a transmission shaft assembly 104 mounted within the housing 102. The housing is articulated to allow the angle of the driven shaft (relative to the drive shaft) of the transmission to be selected by the user.

The housing 102 is comprised of 3 housing elements 106, 108 and 110, which in the orientation shown in Figure 1 are arranged co-axially. The pairs of neighbouring housing elements, eg 106 and 108, and 108 and 110 abut long planes A-A and B-B respectively. Each of the housing elements 106, 108 and 110 have seating surfaces, for example, surface 112 of housing element 116, which are configured to abut against the corresponding seating surface of neighbouring housing element. The housing 102 further includes a passageway 114 extending throughout its length which is configured to receive

the transmission assembly 104 of the transmission 100. The transmission housing 102 has a mounting attachment 116 at is proximal end. The mounting attachment in the present embodiment is formed integrally with the housing element 110 and is configured to be clamped onto a portion of the body of a hand tool to which the transmission 100 is fitted. In the present embodiment the mounting attachment takes the form of a collar that can be clamped on to an annular flange of the hand-tools casing in use to hold the transmission in use.

The proximal end 116 and distal end 118 of the housing each have a stepped internal bore 120 and 122 respectively which are configured to receive a bearing assembly 124 and 126 respectively for holding the transmission assembly 104.

In the present embodiment, the transmission shaft assembly 104 includes 3 main shafts, namely a drive shaft 128, which is mounted at the proximal end of the housing 102, a driven shaft 130, which is mounted at the distal end 118 of the housing and an intermediate shaft 132 that is coupled between the drive shaft 128 and the driven shaft 130. The drive shaft 128 and the driven shaft 130 are coupled to the intermediate shaft 132 via universal joints 134 and 136 respectively. As will be seen, the universal joints 134 and 136 allow the relative angle formed between the drive shaft 128 and the driven shaft 130 to be varied.

In the present embodiment the universal joints 134 and 136 are of a known type typically referred to as a "Hooke's Joint" or "Cardan Joint". As will be appreciated by those skilled in the art other types of universal joints may also be employed in embodiments of the present invention without departing from the scope of the invention. Referring to joint 134, the universal joints 134 and 136 include a pair of orthogonally oriented yokes 138 and 140 which are connected to a central cube or spider 142, by pivot pins, eg 144 and 146 respectively. The intermediate transmission shaft 132 includes a central portion 148 which terminates at either end in the arms of the yoke of the universal joint, e.g. 140.

It should be noted that in present embodiment the effective pivot point of the universal joints 134 and 136 lies in same plane as the abutting seating surfaces of the housing elements 106, 108 and 110, that is, the pivot points of the universal joints lie in

planes A-A and B-B. Thus in use when the housing element rotated about their seating surfaces in either plane A-A or plane B-B the transmission shaft assembly also pivots in that plane, and accordingly the drive shaft assembly remains able to rotate effectively about the axis of each housing element 106, 108 and 110. Such an arrangement minimises the bore size of the central passageway through the housing segments.

In use the transmission 100 is configured to be mounted at the body of a hand tool, in this instance preferably a powered hand drill, or cordless drill. The proximal end 150 of the drive shaft 128 is configured to be coupled to the driveshaft of the hand drill in order to connect the transmission shaft assembly 104 to the drive motor of the hand drill. The distal end 152 of the driven shaft is configured to be coupled to a drill chuck or other tool holder or the like. The means for coupling of the transmission shaft assembly 104 to both the driveshaft/motor of the hand tool, and the drill chuck, can take a variety of forms, as will be appreciated by those skilled in the art and accordingly, the coupling means is not described here in detail.

Various means for maintaining or locking the relative orientation of the housing elements can be used with embodiments of the present invention, including means using a biased detent (e.g. ball) mounted to one of the housing elements that locks into a recess in an abutting housing element, or one or more releasable locking keys. Examples of suitable locking means are described in detail in PCT/IB97/01347 (publication no WO 99/21686) in particular in connection with figures 1 and 2, and figures 5 to 9.

Figure 1B shows the transmission 100 of Figure 1A in a configuration in which the driven shaft 130 lies at an angle α(22.5°) with respect to drive shaft 128. In order to put the transmission 100 into this configuration, the forward most two housing elements 106 and 108 are rotated 180 degrees about plane B-B. Due to the angle that plane B-B forms with the axis of the drive shaft, rotation of the front most housing segments 106 and 108 about plane B-B offsets the axis of the driven shaft with respect to the drive shaft by 45 degrees.

Notwithstanding the reconfiguration of the housing it can be seen that the pivot point of the universal joint 134 remain in plane B-B, and thus the transmission's shafts continue to lie coaxially within their respective housing elements.

As will be appreciated by those skilled in the art a further angular offset of the driven shaft 130 from the drive shaft 128 can be achieved by re-orienting the front most housing element 106 with respect to the intermediate housing element 108. This configuration is shown in Figure 1C. In Figure 1C the front most housing element 106 has been rotated about plane A-A. This results in an off-set angle between the driven shaft 130 and the drive shaft 128 of β which is equal to 90 degrees.

Figure 2 shows a multidirectional transmission 100 according to an embodiment of the present invention mounted on a power drill 200. The transmission 100 is mounted on a generally cylindrical portion 202 of the drill casing 204 by means of its clamping collar 116. On the distal end of the driven shaft 130 is mounted the drill's chuck 206which is adapted to receive drill bits in use.

In this figure the housing elements 106, 108, 110 are aligned coaxially and the axis of rotation of the drive shaft and the driven shaft are aligned.

Figure 2A shows the transmission of figure 2 in a different selected configuration. This configuration essentially corresponds to that of figure 1B, in that the housing has been rotated about plane B-B such that the driven shaft (drill chuck) will operate at an angle of about 45 degrees to the drive shaft (drill body) of the transmission 100.

Figure 2B shows an alternative configuration for achieving a 45 degree offset between the drill chuck and drill body (i.e. the driven shaft of the transmission and the drive shaft of the transmission). In this configuration the offset has been achieved by rotating the front-most housing element 106 relative to the intermediate housing element 108 about plane A-A.

The configuration of figure 2C corresponds to that of Figure 1C, and shows the drill chuck being set at an angle of 90 degrees to the drill body (i.e. the driven shaft of the transmission is set at an angle of 90 degrees to the drive shaft of the transmission). As described above this configuration is achieved by rotating housing element 106 90 degrees in plane A-A relative to housing element 108, and by rotating housing element 108 90 degrees in plane B-B relative to housing element 110.

As will be appreciated a wide range of angular offsets between the driven shaft and the drive shaft can be achieved by partially rotating the housing elements of the transmission. In the present embodiment the angles between 0 and 90 degrees are attainable. However by adding additional intermediate housing elements and transmission shafts greater angular offsets are possible.

Figure 3 shows the transmission in yet another angular configuration. As will be seen the drill chuck is set to operate at an angle of 90 degrees from the axis of the body, however rather than being offset in an "upward" direction as shown in figure 2C the drill chuck is offset to the right of the drill body by 90 degrees. This configuration is attained by arranging the transmission housing elements as shown in figure 2C and by also rotating the transmission assembly by 90 degrees relative to the body of the drill 200.

The clamping collar used on the preferred embodiment allows the angular orientation of the housing relative to the body of the drill to be selected in a straightforward manner. A close-up view of a preferred clamping collar that can be used to mount a transmission 100 to a hand tool is shown in figure 4. The clamping collar arrangement 116 is formed integrally with the proximal housing element 110 and comprises a flange 400extending from the housing element that forms a split cylindrical collar having an outer diameter larger than the main body of the housing element 110. The collar has a stepped bore 120 extending through it which is configured to receive and retain a bearing for holding the drive shaft 128 (not shown).

The clamping collar 116 is able to slid onto a receiving collar or flange on the body of a power tool and be tightened into place using screw 402. By tightening screw 402 the effective internal diameter of the bore 120 is reduced causing the clamping collar to be clamped onto the receiving collar or flange of the hand tool.

In use a user can change the orientation of the transmission relative to the hand-tool on which it is mounted by loosening the screw 402, realigning the transmission into the new desired orientation and re-tightening the screw 402.

The present inventors have found that using the transmission arrangement described does not become appreciably more prone to failure as its length is increased, as

opposed to cable drive transmissions. Therefore it has been found that transmission of lengths of up to 0.5 metres can be constructed.

The inventors have also discovered that hammer drilling can be performed with embodiments of the present invention, which is not possible with transmissions incorporating flexible drive cables as the cable cannot transmit the impact force to the drill bit without deformation.

The embodiment described above has been described in connection with a transmission to be fitted to an existing drill body, either as original equipment, or as an aftermarket retrofitted attachment, however it should be noted that embodiments can be incorporated into a hand tool as an integral component, e.g. as part of the housing of the tool. In such an embodiment the transmission body element housing the drive shaft can be integrally formed with the hand tool's housing.

It will be understood that the invention disclosed and defined herein extends to all alternative combinations of two or more of the individual features mentioned or evident from the text or drawings. All of these different combinations constitute various alternative aspects of the invention.

The foregoing describes embodiments of the present invention and modifications, obvious to those skilled in the art can be made thereto, without departing from the scope of the present invention.

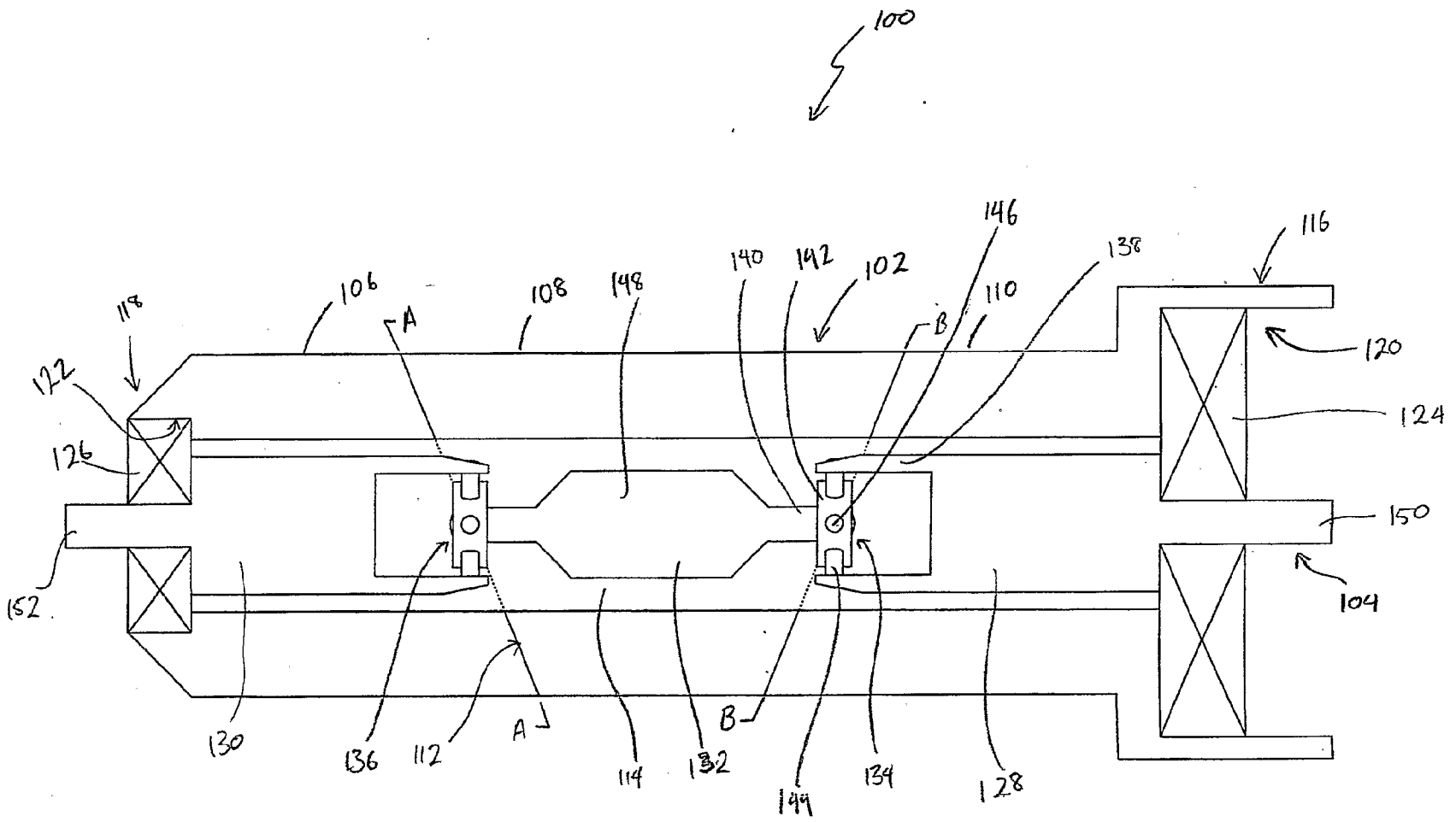
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FIG. 1A

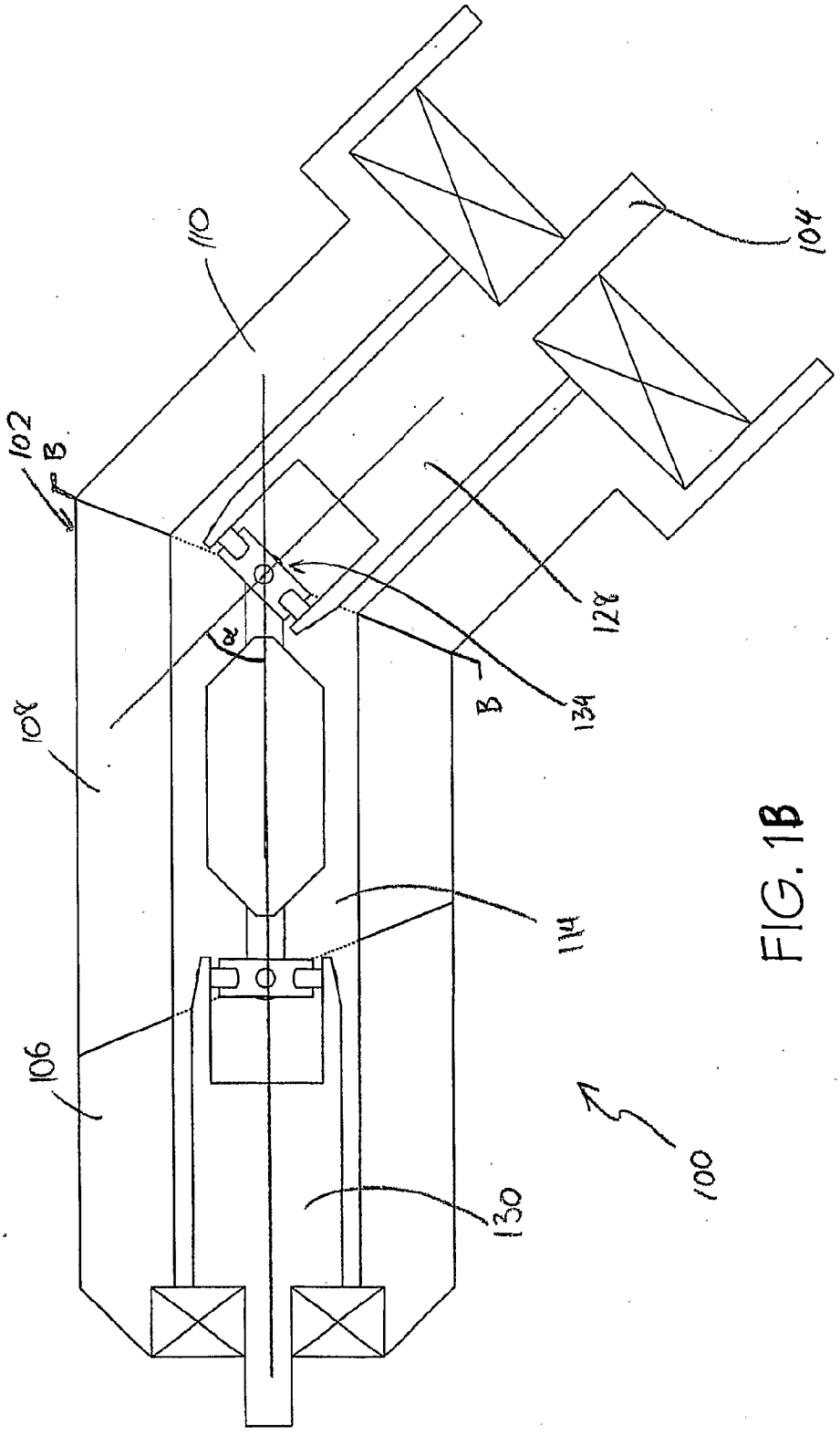

FIG. 1B

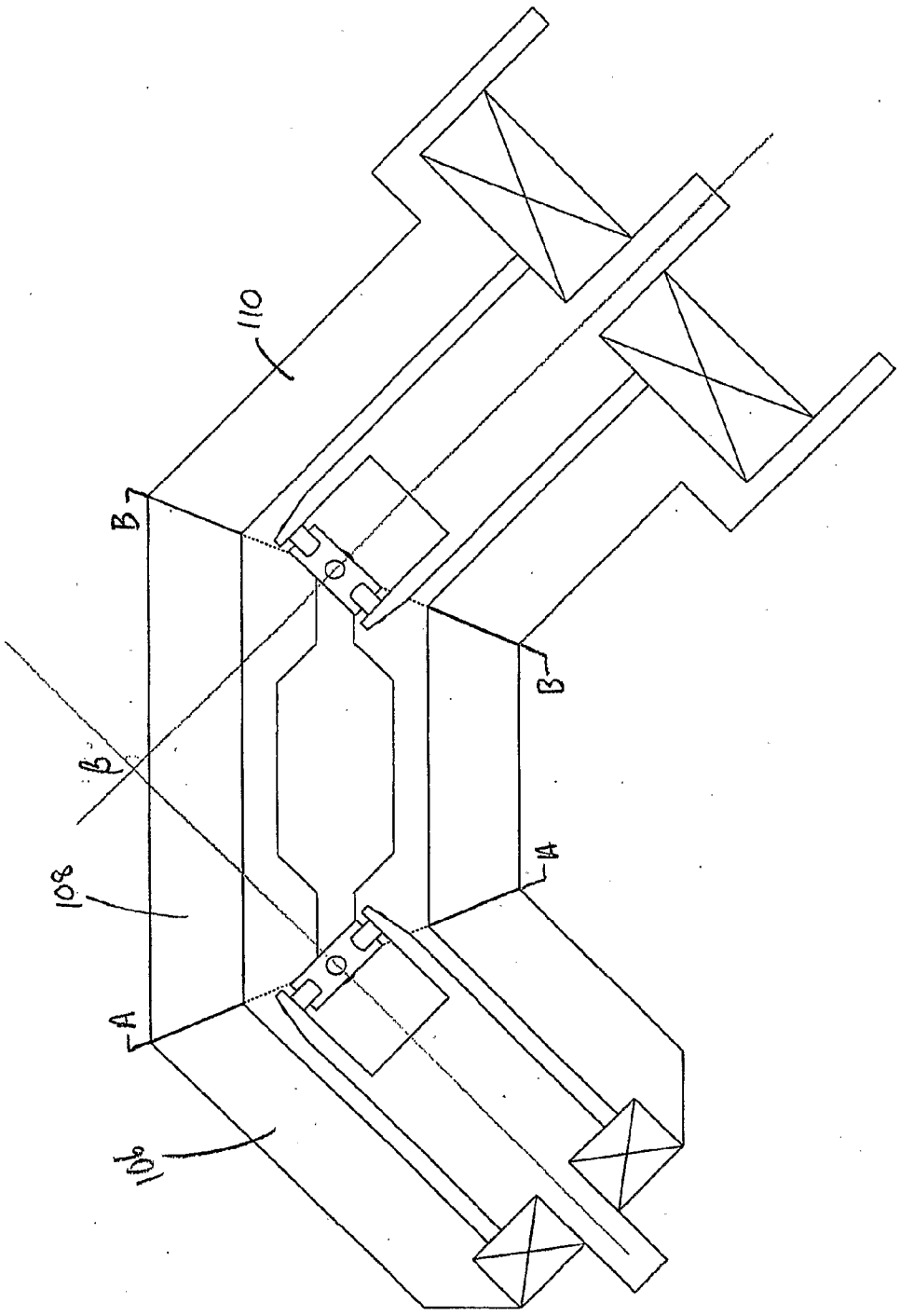

FIG. 1C

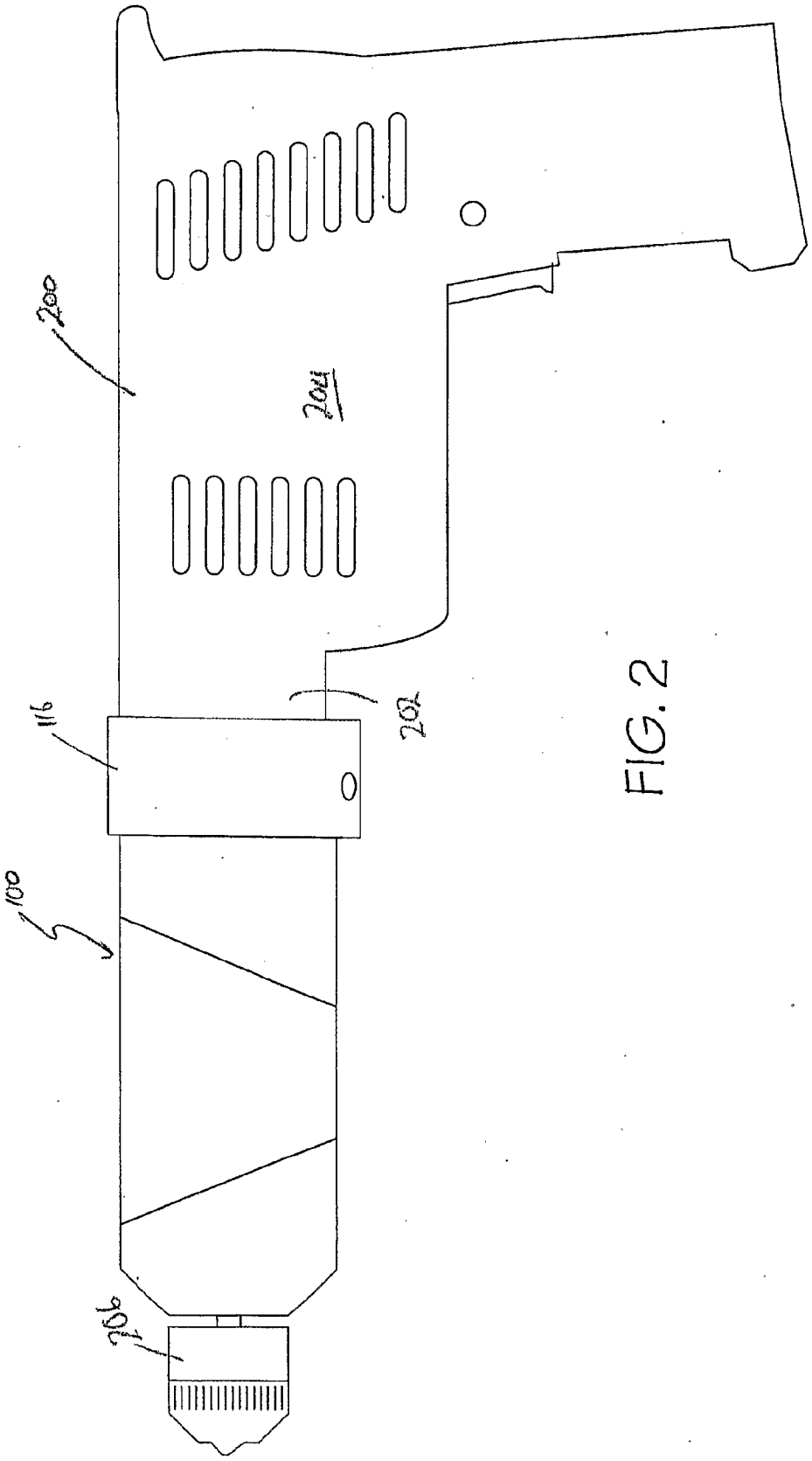

FIG. 2

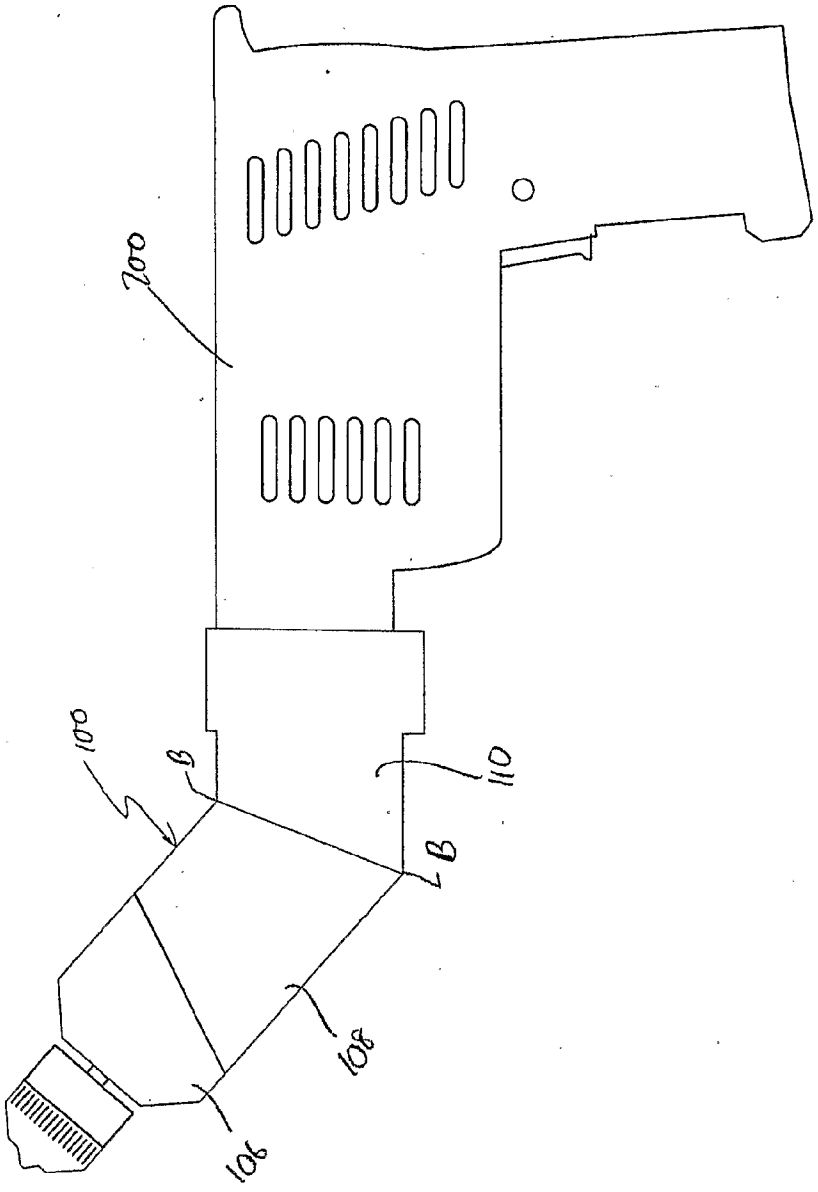

FIG. 2A

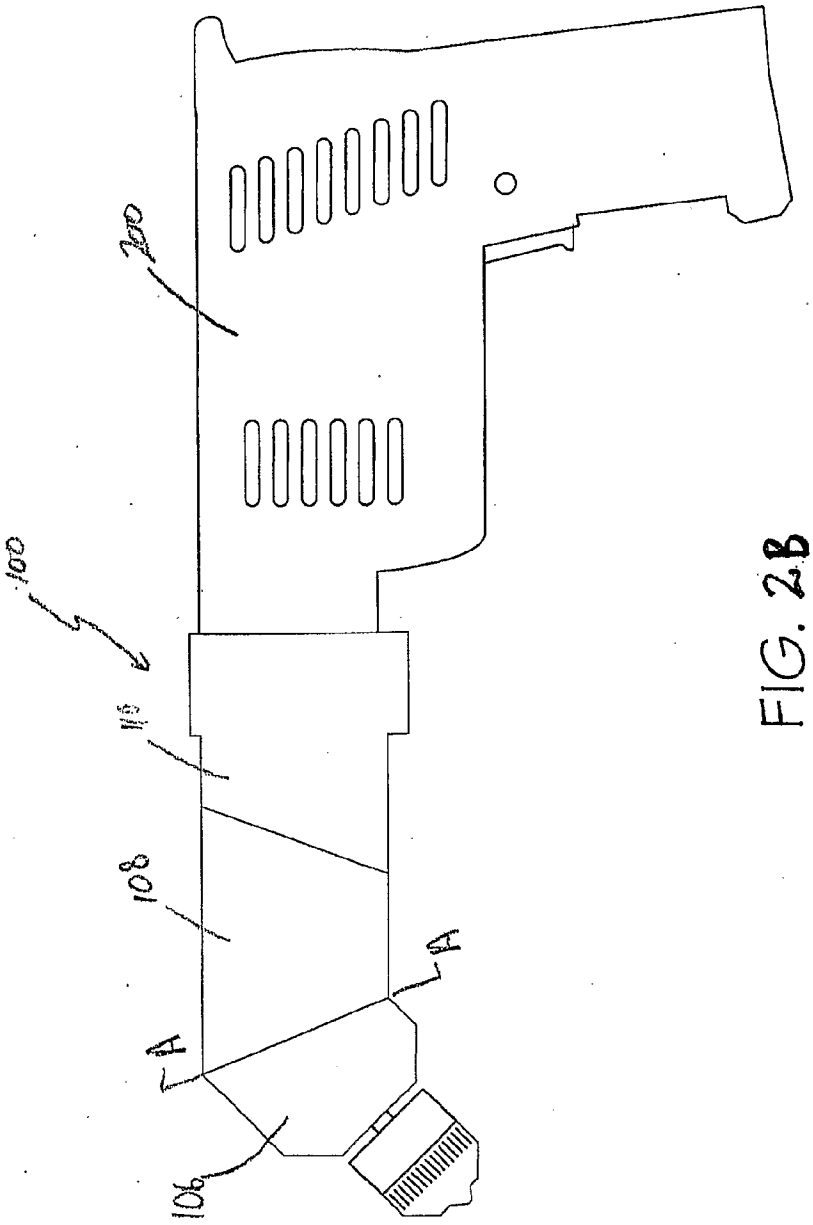

FIG. 2B

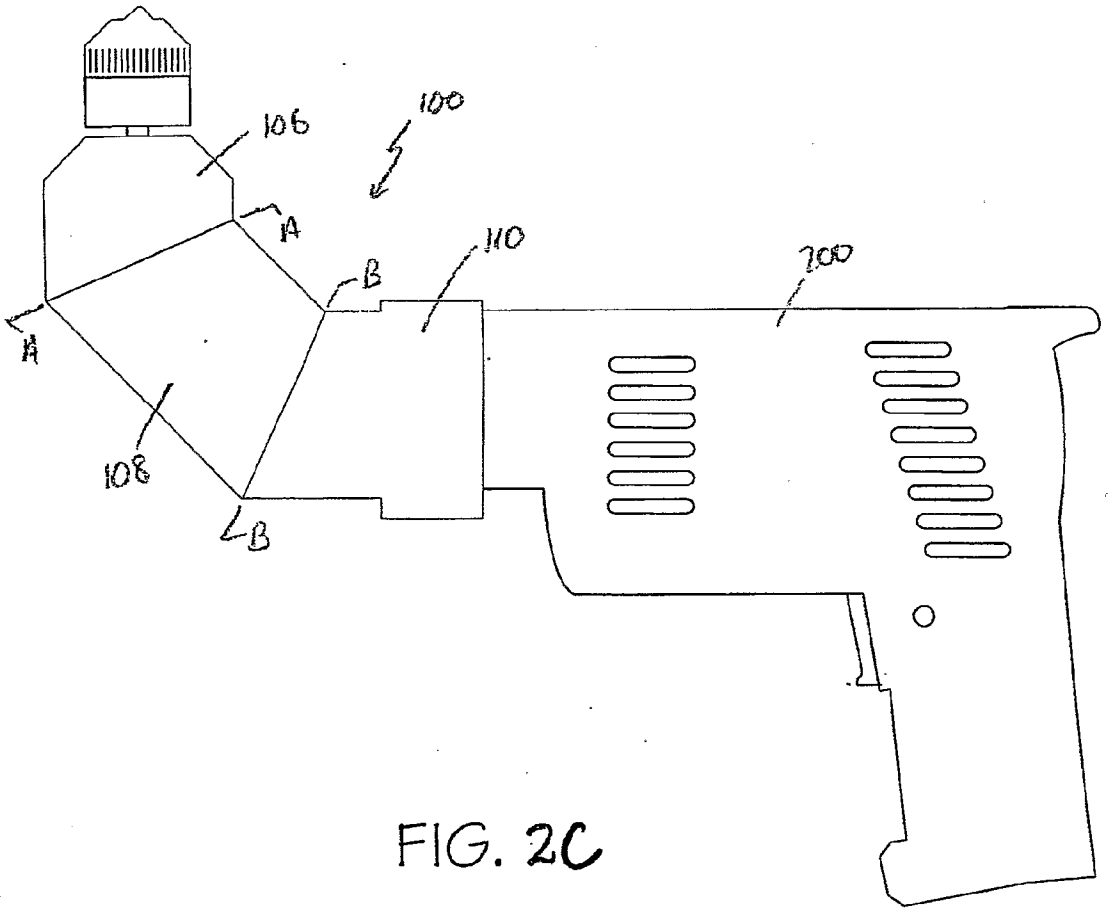

FIG. 2C

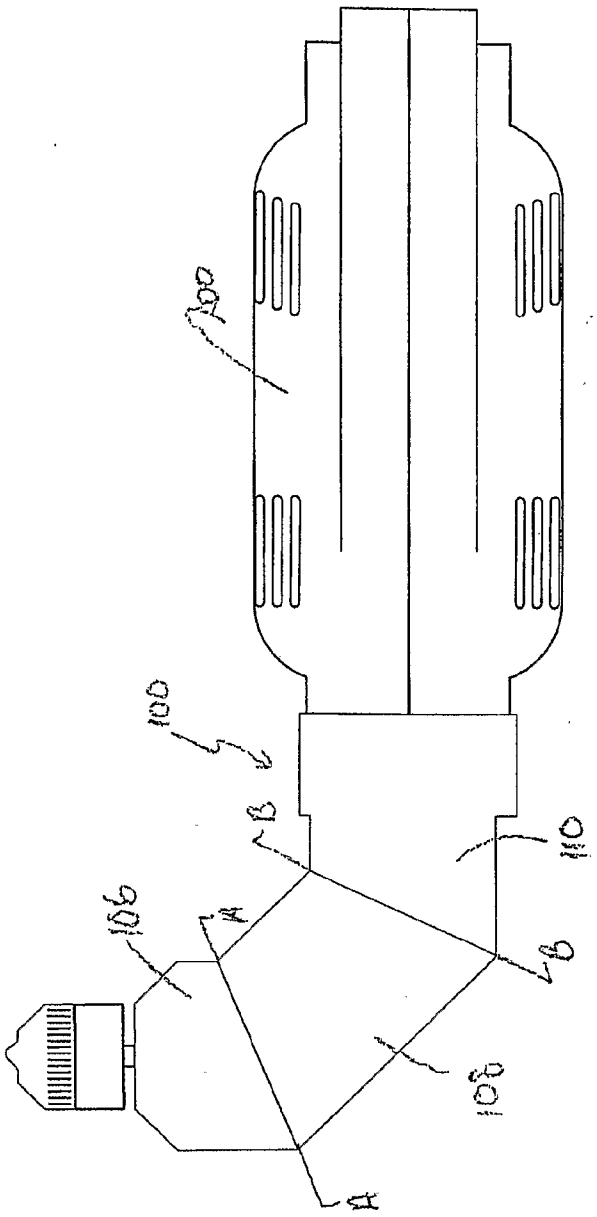

FIG. 3

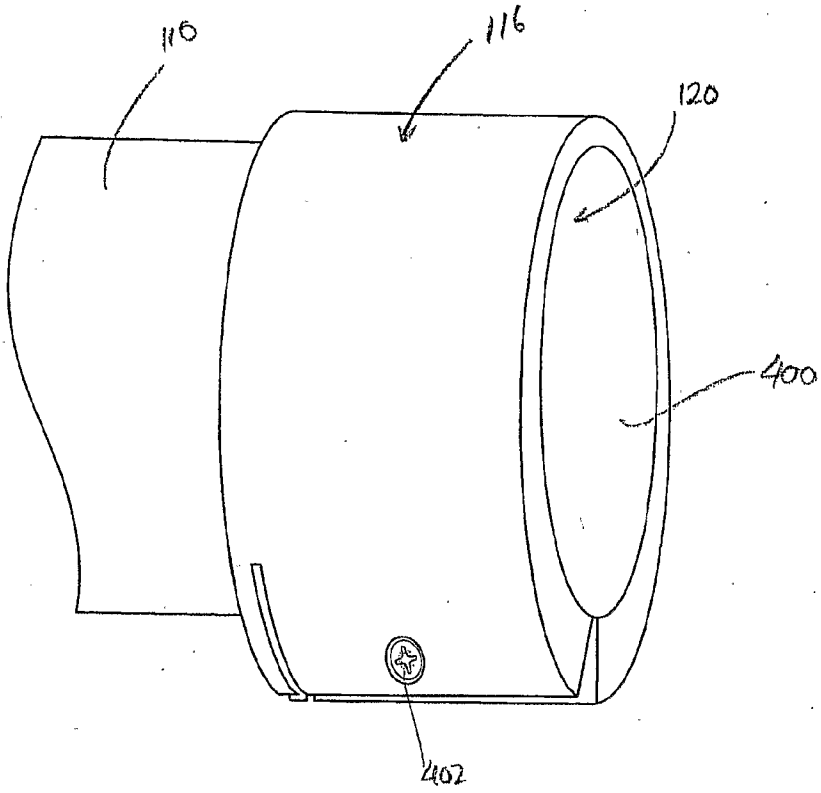

FIG: 4